IP
Static Routing
dynamic routing
RIP protocol

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IP routing table

- Routing table contain one or more *route*
- Route is entry in routing table containing information how to reach IP Network called
  - `Network to reach` – netmask – *next hop* – metric
    - *Example:* `10.1.1.0` 255.255.255.0 *10.10.1.2* *5*
- A connected network it's automatically learned by the router:
  - Router deduce the connected network looking at interface network and netmask
  - The connected network is present in the routing table only if the interface is up

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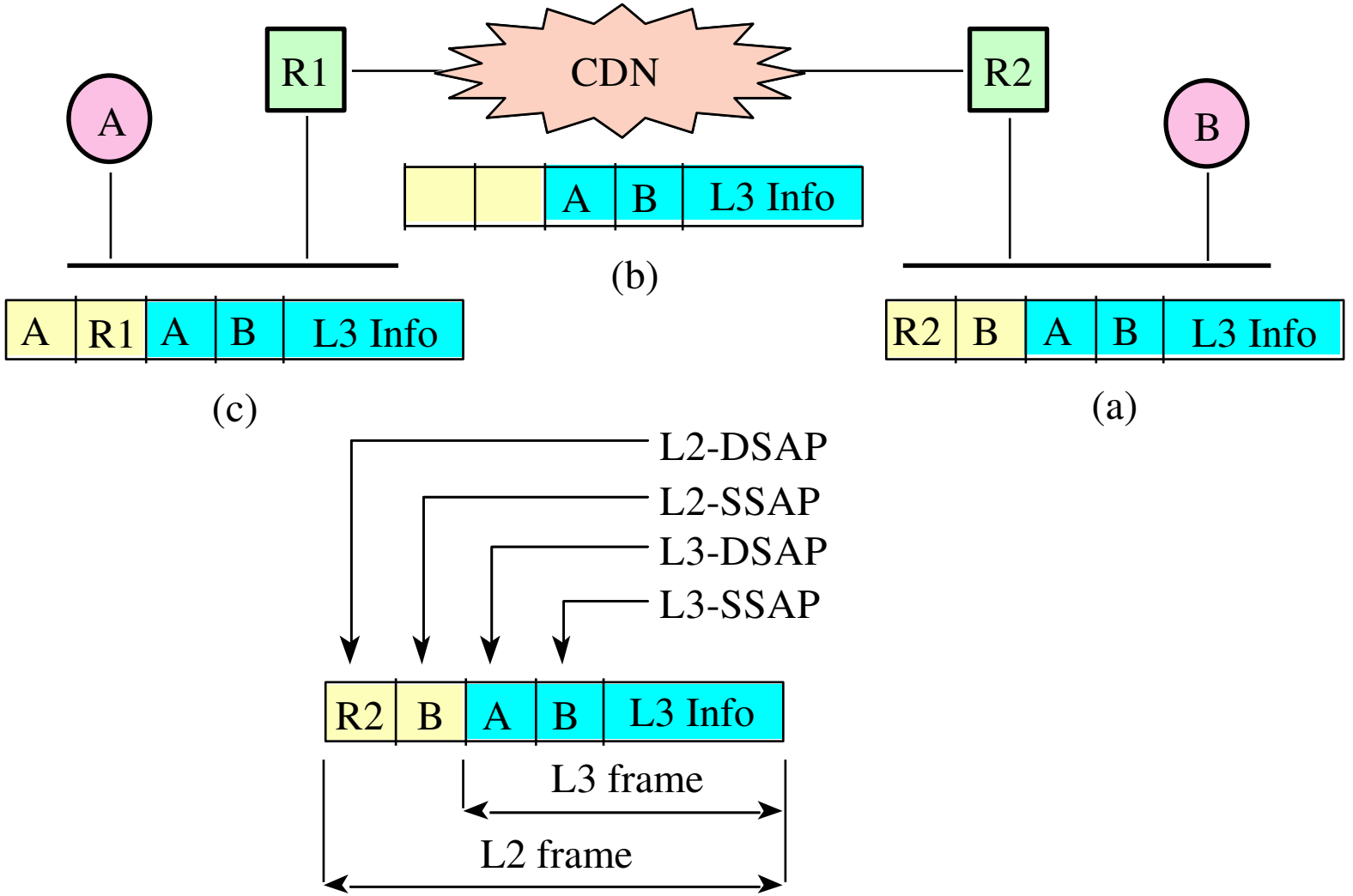
Level 2, level 3 address and routing



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Static routing

- Router may have static routing information on a *Routing Table*
  - The *static route* are configured by network manager and stored in the configuration file
    - The configuration file it's loaded at router bootstrap in RAM and the routing information are loaded in the routing table

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Dynamic routing

- Router may have dynamic routing information's on a *Routing Table*
  - A specific routing protocol send routing information's on the active interfaces that are necessary to establish the route to reach the networks
    - The routing algorithm contain the rules how to determine the route
- Dynamic routing algorithm
  - Distance Vector
  - Link State Packet

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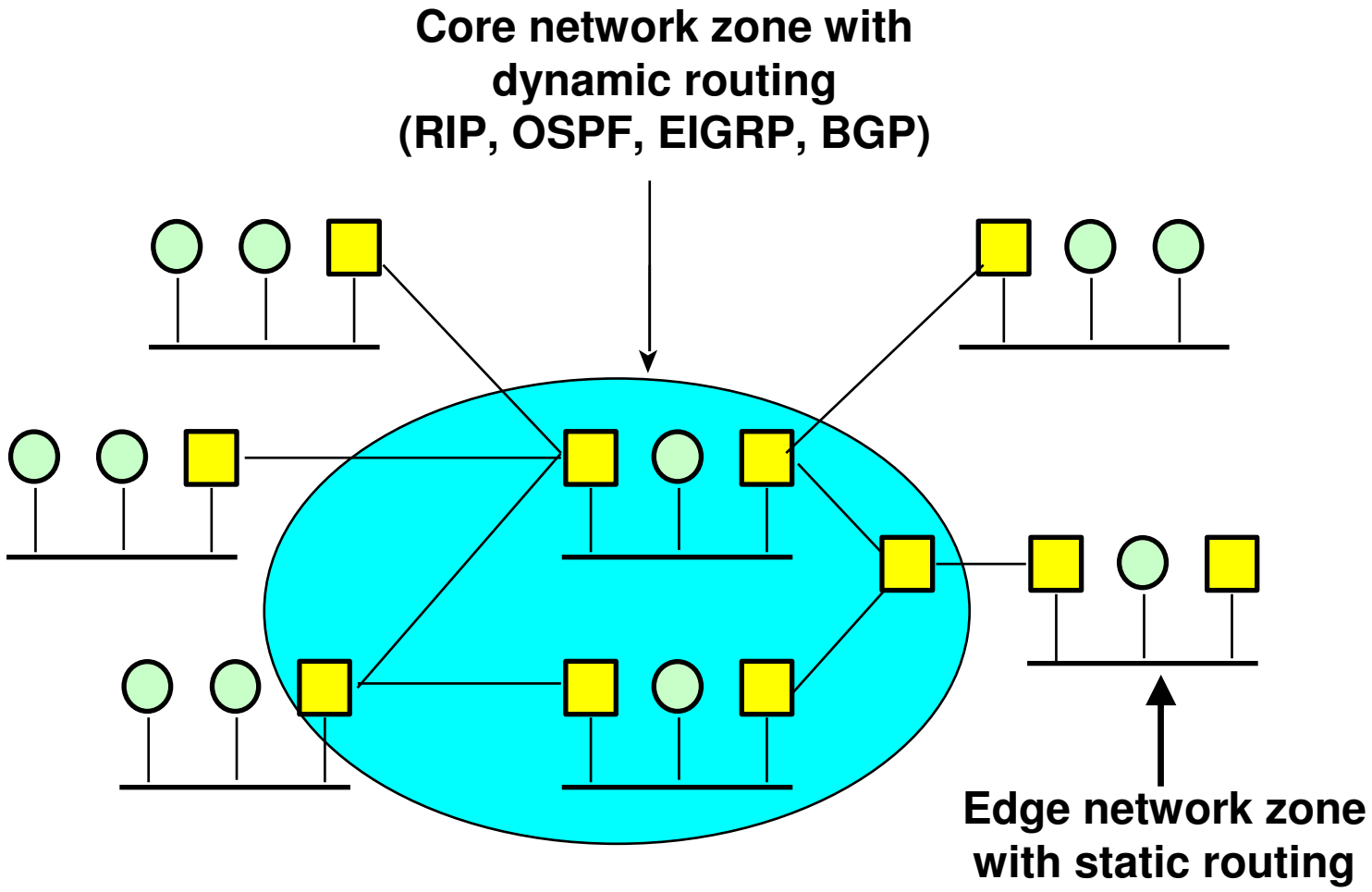
Static & Dynamic Routing



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Static route configuration example

```
2503a#config term
Enter configuration commands, one per line.  End with CNTL/Z.
```

Static route configuration command

Network to reach

Netmask

next hop address

```
2503a(config)#ip route 192.168.64.0 255.255.255.0 192.168.3.9
2503a(config)#ip route 192.168.67.0 255.255.255.0 192.168.3.9
2503a(config)#ip route 192.168.16.0 255.255.255.0 192.168.3.9
2503a(config)#ip route 192.168.2.0 255.255.255.0 192.168.1.2
```


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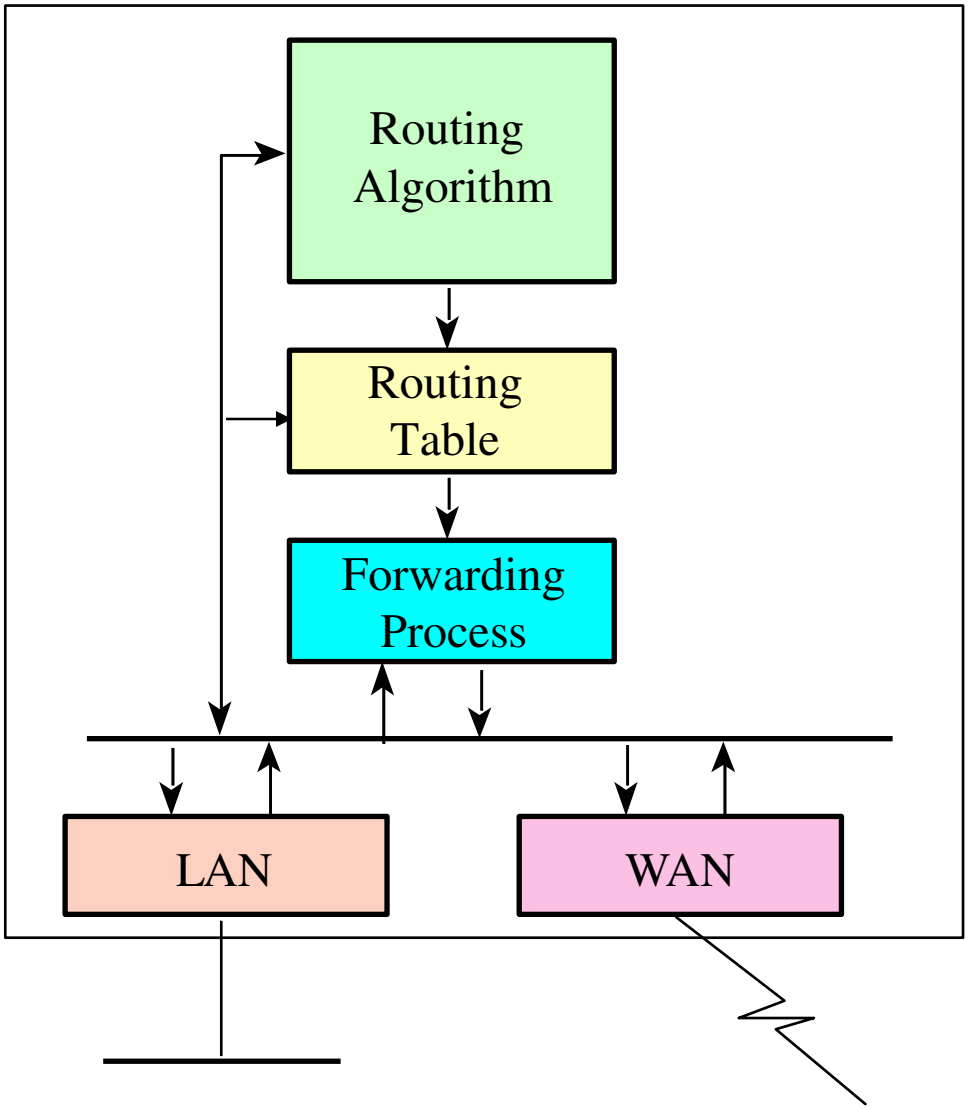
Router architecture



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Distance Vector

- Know as Bellman-Ford algorithm
- Any node when modify own routing table send a distance vector to the adjacent node
- Distance vector it's a pairs assembly containing
  - [network address – distance]
- Distance use classic metric like hop and cost
- Any node or router store the last distance vector received on any interface

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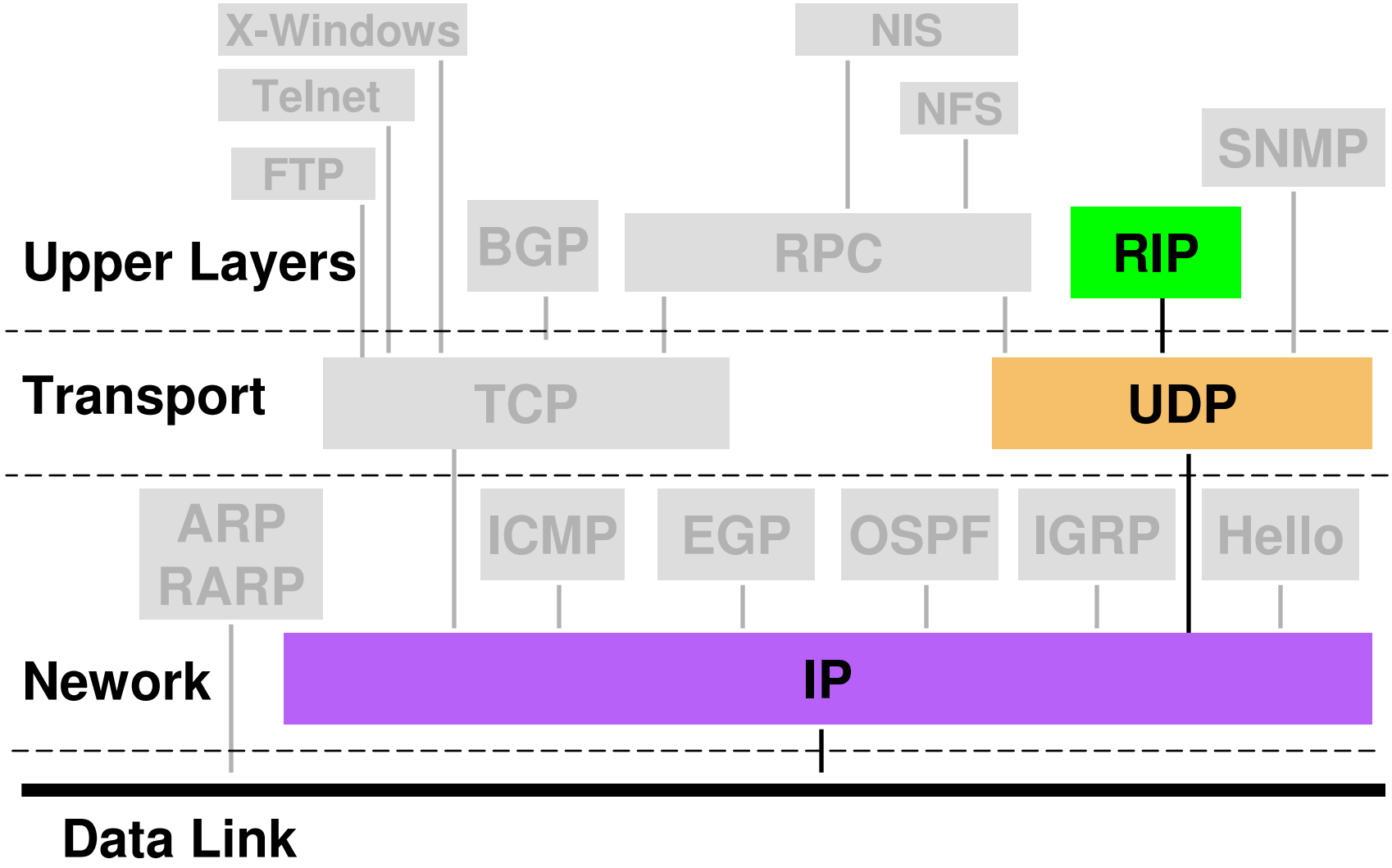
RIP routing protocol and stack IP



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RIP

- Developed by Xerox for XNS
- Modified in 1982 il RIP to work with TCP/IP
- Distance vector routing protocol hop based
- RIP defined by IETF on RFC 1058 in 1988 and RFC 1388 in 1993

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RIP

- Metric based on hop count
  - Maximum 15 hop admitted
    - Metric 16 = network unreachable
- Any router count as 1 hop
- Update routing message: any 30 s
- In case of link failure or topology change a router send immediately a routing update
- Convergence routing time typical 5 minutes

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RIP v1, Routing & netmask

- RIP v1 protocol do not transport netmask information
  - limits:
    - All subnet of the same network class must have the same netmask
    - It's not possible use a IP address planning based on variable subnetting
- Broadcast routing protocol message

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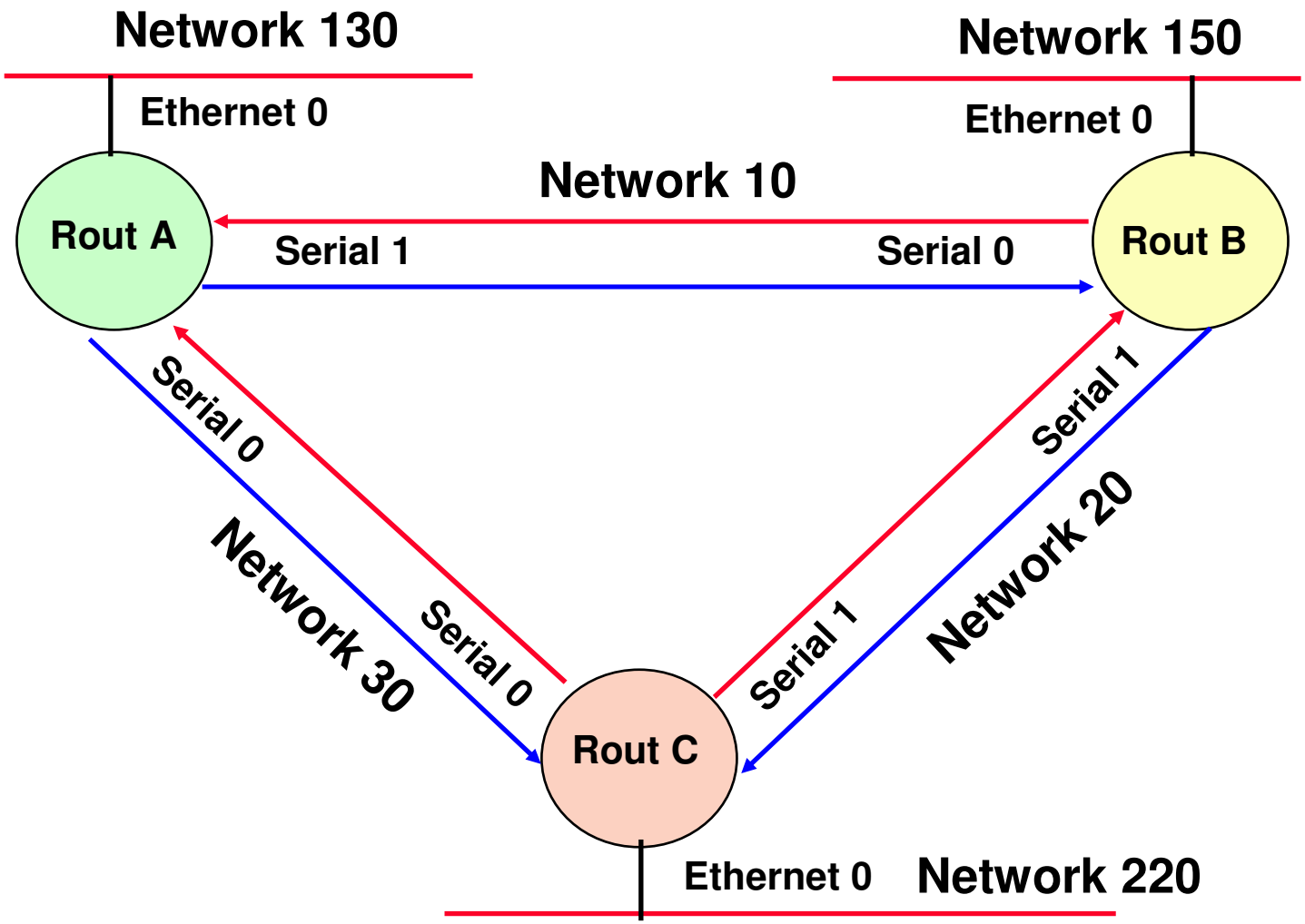
WAN example with RIP



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Router A: cold start and announces

Serial 0

Address	Cost
130	1
10	1
30	1

Serial 1

Address	Cost
130	1
10	1
30	1

Router A routing table

Address	Cost	Line
130	1	Conn.
10	1	Conn.
30	1	Conn.

Ethernet 0

Address	Cost
130	1
10	1
30	1

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Router B: cold start and announces

Serial 0

Address	Cost
150	1
10	1
20	1

Serial 1

Address	Cost
150	1
10	1
20	1

Router B routing table

Address	Cost	Line
150	1	Conn.
10	1	Conn.
20	1	Conn.

Ethernet 0

Address	Cost
150	1
10	1
20	1

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Router C: cold start and announces

Serial 0

Address	Cost
220	1
20	1
30	1

Serial 1

Address	Cost
220	1
20	1
30	1

Router C routing table

Address	Cost	Line
220	1	Conn.
20	1	Conn.
30	1	Conn.

Ethernet 0

Address	Cost
220	1
20	1
30	1

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Router A: routing announces received by B

Serial 1

Address	Cost
130	2
10	1
20	1
30	2
150	1
220	2

Router A routing table

Address	Cost	Line
130	1	Conn.
10	1	Conn.
30	1	Conn.
20	2	Ser.1
150	2	Ser.1
220	3	Ser.1

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Router A: routing announces received by C

Address	Cost
220	1
20	1
30	1
10	2
130	2
150	2

Serial 0

Router A routing table

Address	Cost	Line
130	1	Conn.
10	1	Conn.
30	1	Conn.
20	2	Ser.1
150	2	Ser.1
220	2	Ser.0

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Router B: routing announces received by A

Address	Cost
130	1
10	1
30	1
20	2
150	2
220	2

Serial 0

Router B routing table

Address	Cost	Line
150	1	Conn.
10	1	Conn.
20	1	Conn.
130	2	Ser.0
30	2	Ser.1
220	2	Ser.1

Route previously learned by router C

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Router B: routing announces received by C

Serial 1

Address	Cost
220	1
20	1
30	1
150	2
10	2
130	2

Router B routing table

Address	Cost	Line
150	1	Conn.
10	1	Conn.
20	1	Conn.
130	2	Ser.0
30	2	Ser.1
220	2	Ser.1

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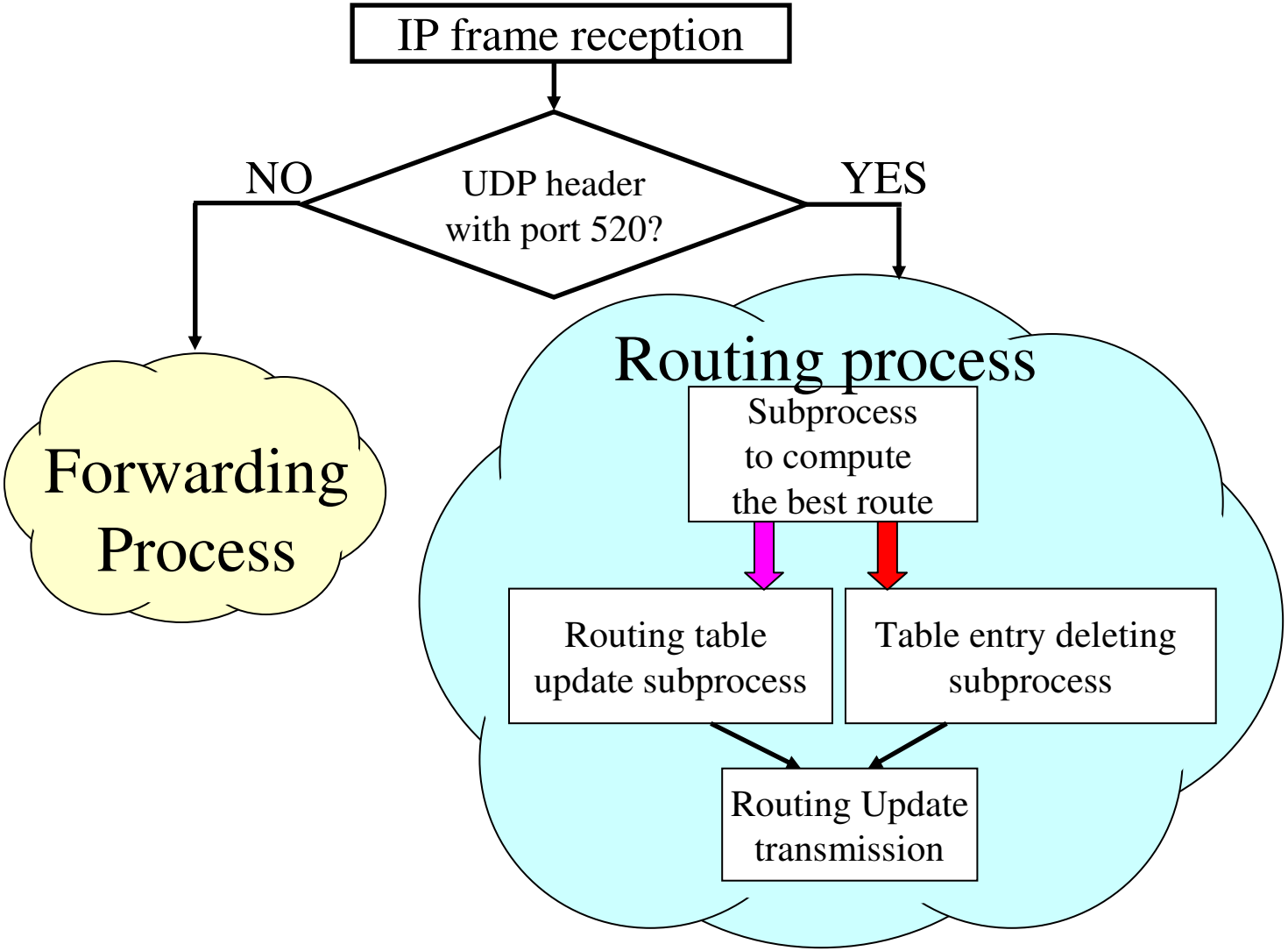
Router RIP



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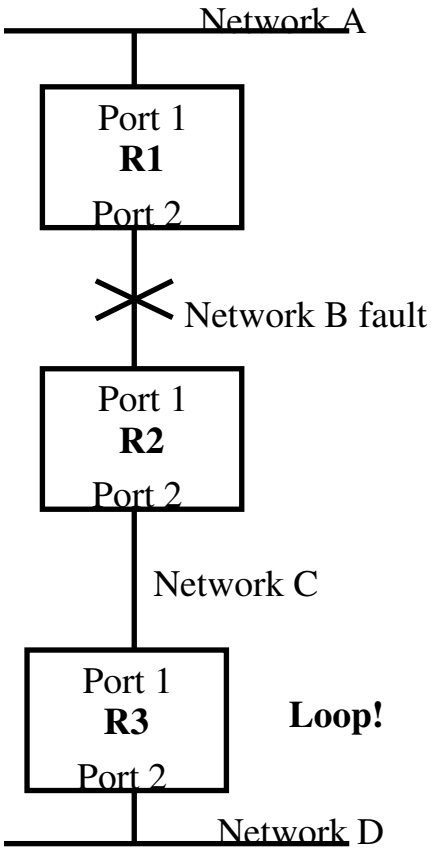
Fault and lost Routing Update

- When fault happen:
  - adjacent routers to faulty line set the route of faulty network to metric = 16 (unreachable)
- When router do not receive information about a route and the associated timer expire (timeout)
  - Router consider the route unreachable and set a metric to value 16



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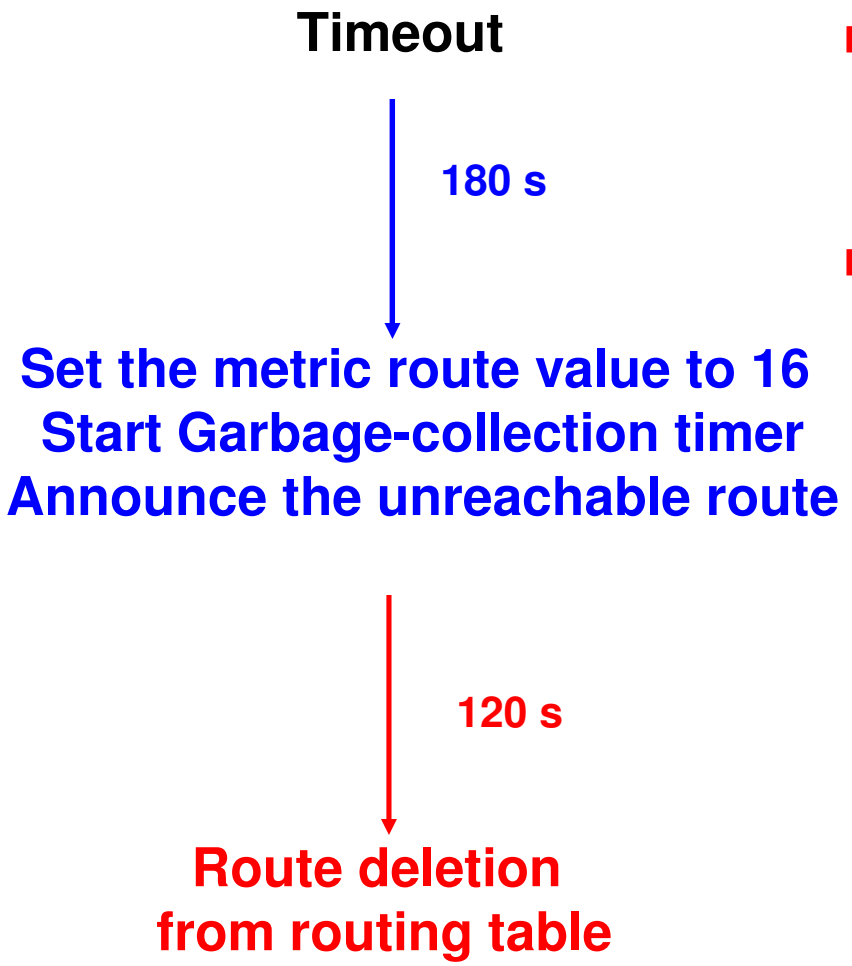
Lost Routing Update



- Timeout or *route-timer* or *invalid timer*
  - Maximun time for valid route
- Garbage-collection timer or *hold-down-timer*
  - Time period to announce a route with metric 16
  - Time to wait route deletion

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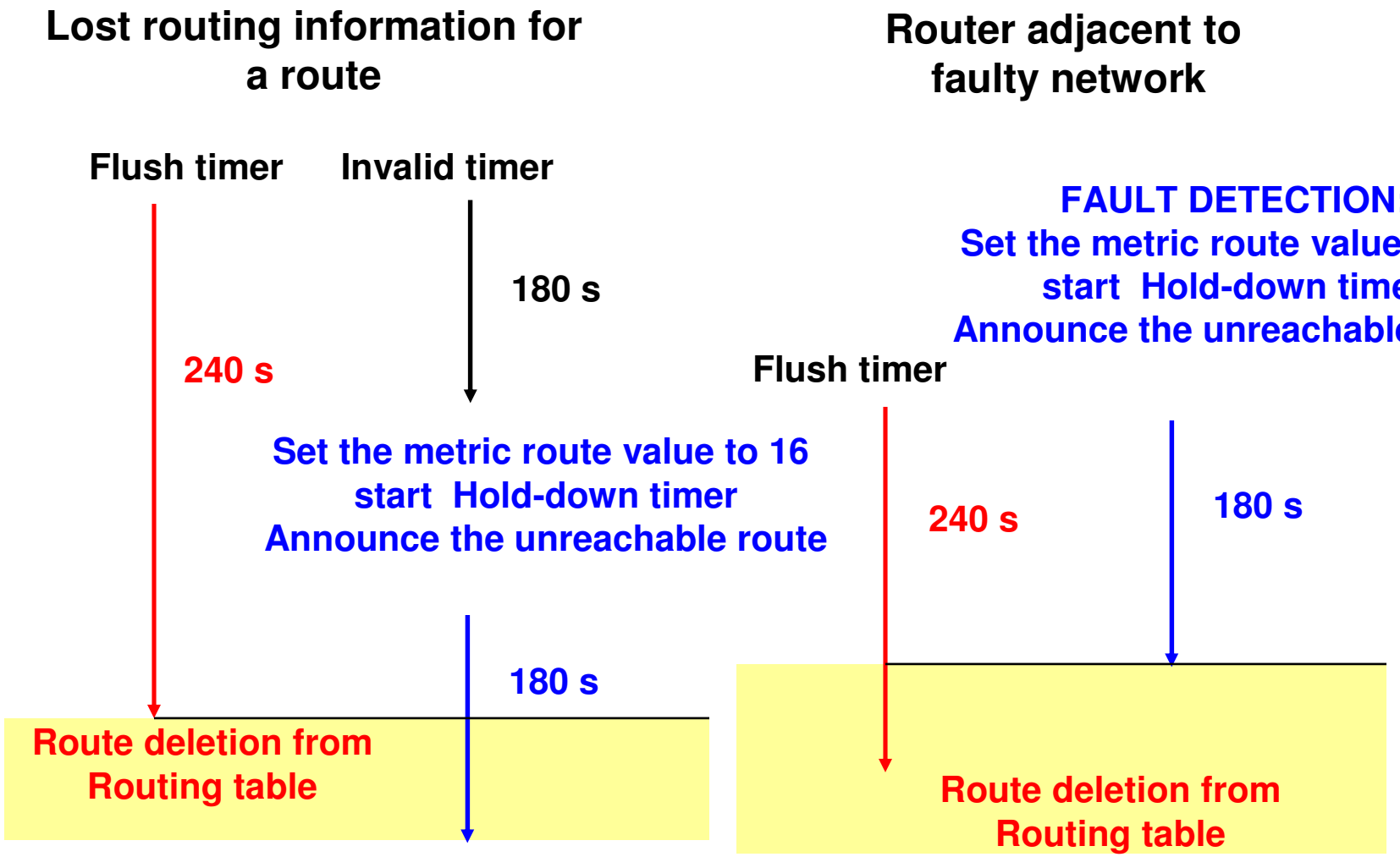
Router Cisco and RIP timer



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Split horizon

- Do not send route information's learned from that link
- Prevent loop
- Speed-up the convergence

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Split Horizon with poisonous reverse

- Router send the route learned from that link with ∞ Cost (metric =16)
- Prevent loop
- Speed-up the convergence
- Better convergence loop prevention than simple split horizon function

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RIPv1 packet format

command	version	must be zero
address family identifier		must be zero
IP address		
must be zero		
must be zero		
metric		

Address Family ID & Metric can be repeated up to 25 times

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RIP v1 packet fields

- Command
  - request = 1
    - Used during cold start to request distance vector
  - response = 2
    - Used to distribue distance vector
- Version = 1
- Address Family
  - IP = 2

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RIP packet transport

- Maximum packet length = 512 octets
- Transport UDP header
  - port 520
- Broadcast destination address

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RIPv2

- RFC 1723
- Same algorithm than RIP-1 just change the packet information's
  - Netmask transport information's
  - Router can operate with both RIP version just use different RIP packet depending by RIP version of adjacent router

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RIPv2 packet format

command	version	routing domain
address family identifier		route tag
IP address		
subnet mask		
next hop		
metric		

Address Family ID & Metric can be repeated up to 25 times

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Il pacchetto RIPv2

- Version = 2
- Address Family
  - New information “authentication data”
- Routing Domain
  - AS number
  - Can operate with more AS on the same network
- Routing Tag
  - For external router using EGP or BGP
- Multicast destination address
  - 224.0.0.9

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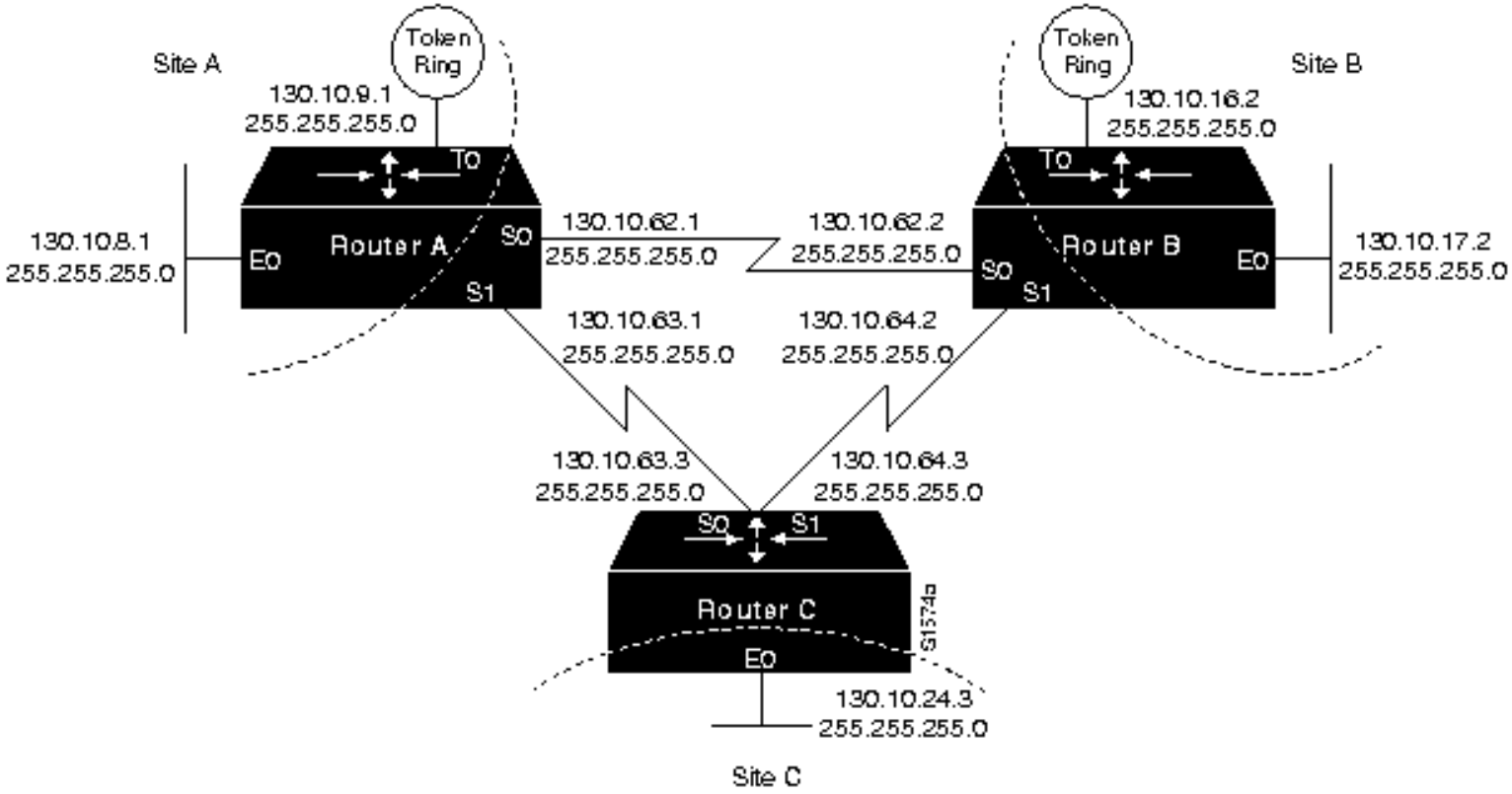
Network example with RIP



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Router A configuration

```
interface serial 0
ip address 130.10.62.1 255.255.255.0
!
interface serial 1
ip address 130.10.63.1 255.255.255.0
!
interface ethernet 0
ip address 130.10.8.1 255.255.255.0
!
interface tokenring 0
ip address 130.10.9.1 255.255.255.0
!
router rip
network 130.10.0.0
```


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Router B configuration

```
interface serial 0
ip address 130.10.62.2 255.255.255.0
!
interface serial 1
ip address 130.10.64.2 255.255.255.0
!
interface ethernet 0
ip address 130.10.17.2 255.255.255.0
!
interface tokenring 0
ip address 130.10.16.2 255.255.255.0
!
router rip
network 130.10.0.0
```


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Router C configuration

```
interface serial 0
ip address 130.10.63.3 255.255.255.0
!
interface serial 1
ip address 130.10.64.3 255.255.255.0
!
interface ethernet 0
ip address 130.10.24.3 255.255.255.0
!
router rip
network 130.10.0.0
```


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RIPv2 configuration example

```
key chain flintstone
 key 1
  key-string fred
 key 2
  key-string barney
  accept-lifetime 00:00:00 Dec 5 1995 23:59:59 Dec 5 1995
  send-lifetime 06:00:00 Dec 5 1995 18:00:00 Dec 5 1995
!
interface Ethernet0
 ip address 172.19.104.75 255.255.255.0 secondary
 ip address 171.69.232.147 255.255.255.240
 ip rip authentication key-chain flintstone
!
interface Fddi0
 ip address 2.1.1.1 255.255.255.0
 no keepalive
!
interface Fddi1
 ip address 3.1.1.1 255.255.255.0
 ip rip send version 1
 ip rip receive version 1
!
router rip
 version 2
 network 172.19.0.0
 network 2.0.0.0
 network 3.0.0.0
```


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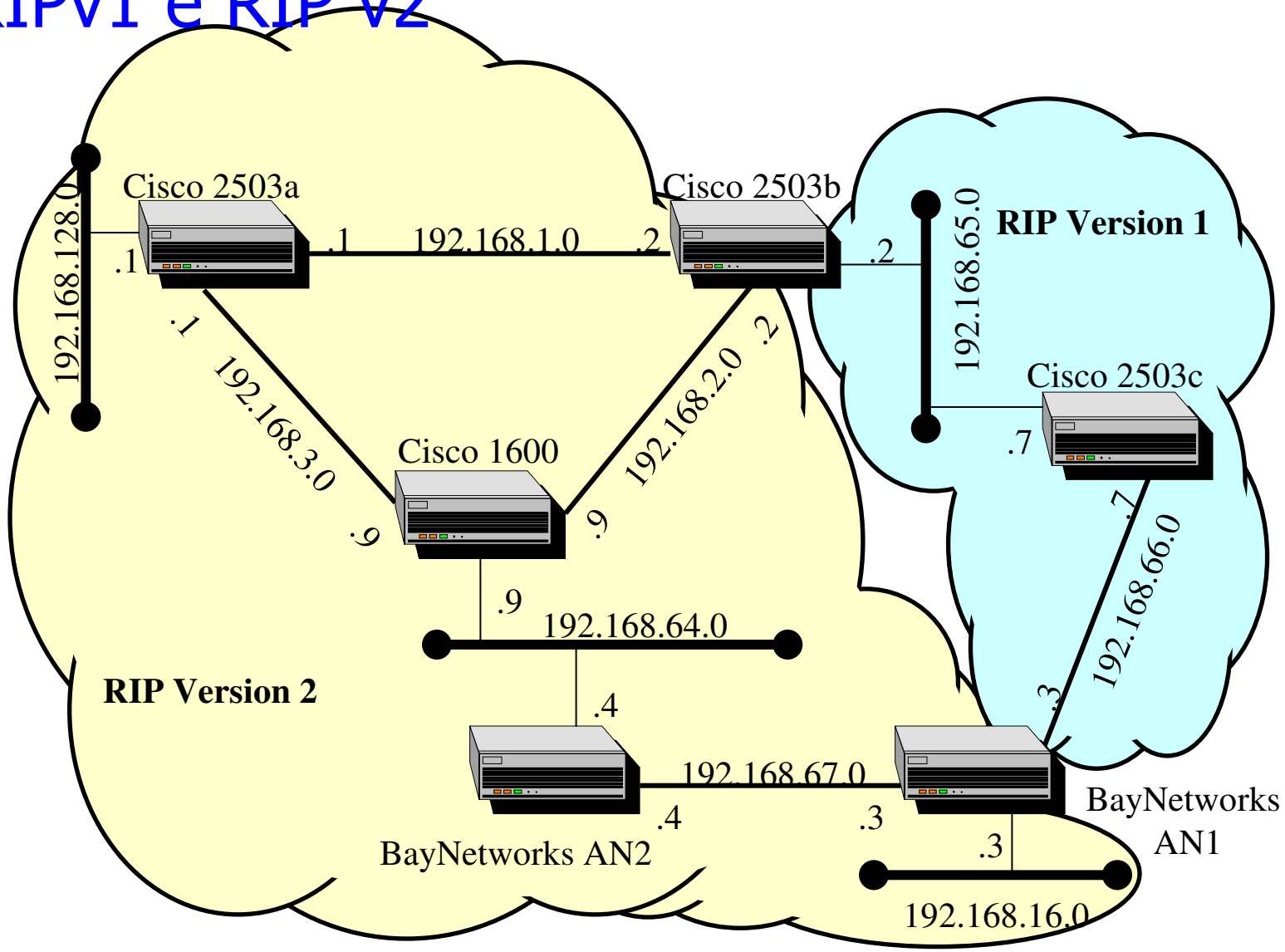
RIPv1 e RIP v2



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Link State

- Any router learn locally: adjacent router and link that connect them
  - Continuos transmission of hello packet to know the adjacency
- Transmit adjacency information to the connected router trough Link State Packet (LSP)
- Router store LSP in a Database and use the information to build up the network map
- Router use the information's regarding network map to define the route and insert in the routing table

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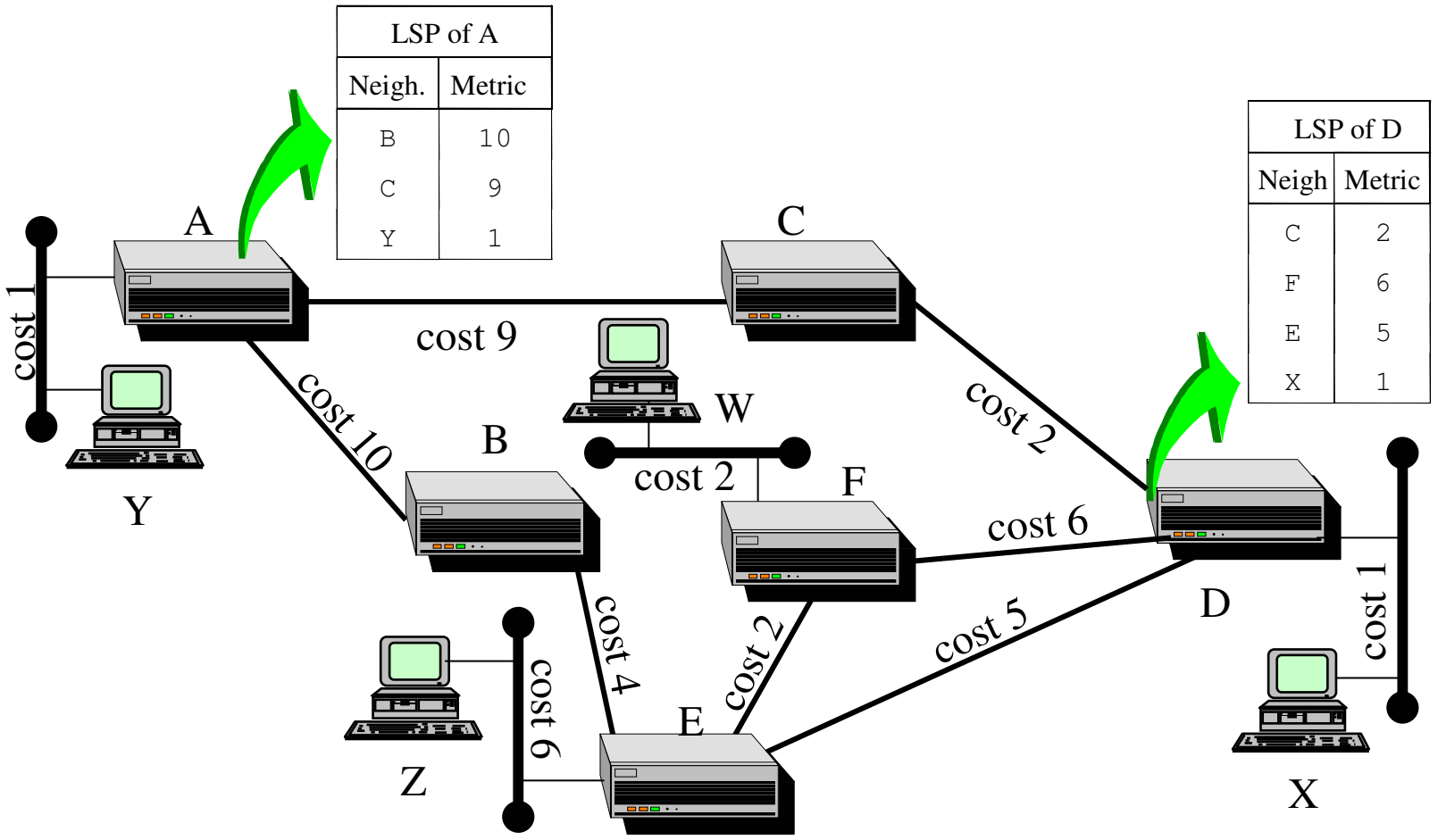
Link state packet example



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LSP data base

Source	Node/Cost
A	B/10 C/9 Y/1
B	A/10 E/4
C	A/9 D/2
D	C/2 E/5 F/6 X/1
E	B/4 F/2 Z/6 D/5
F	D/6 E/2 W/2

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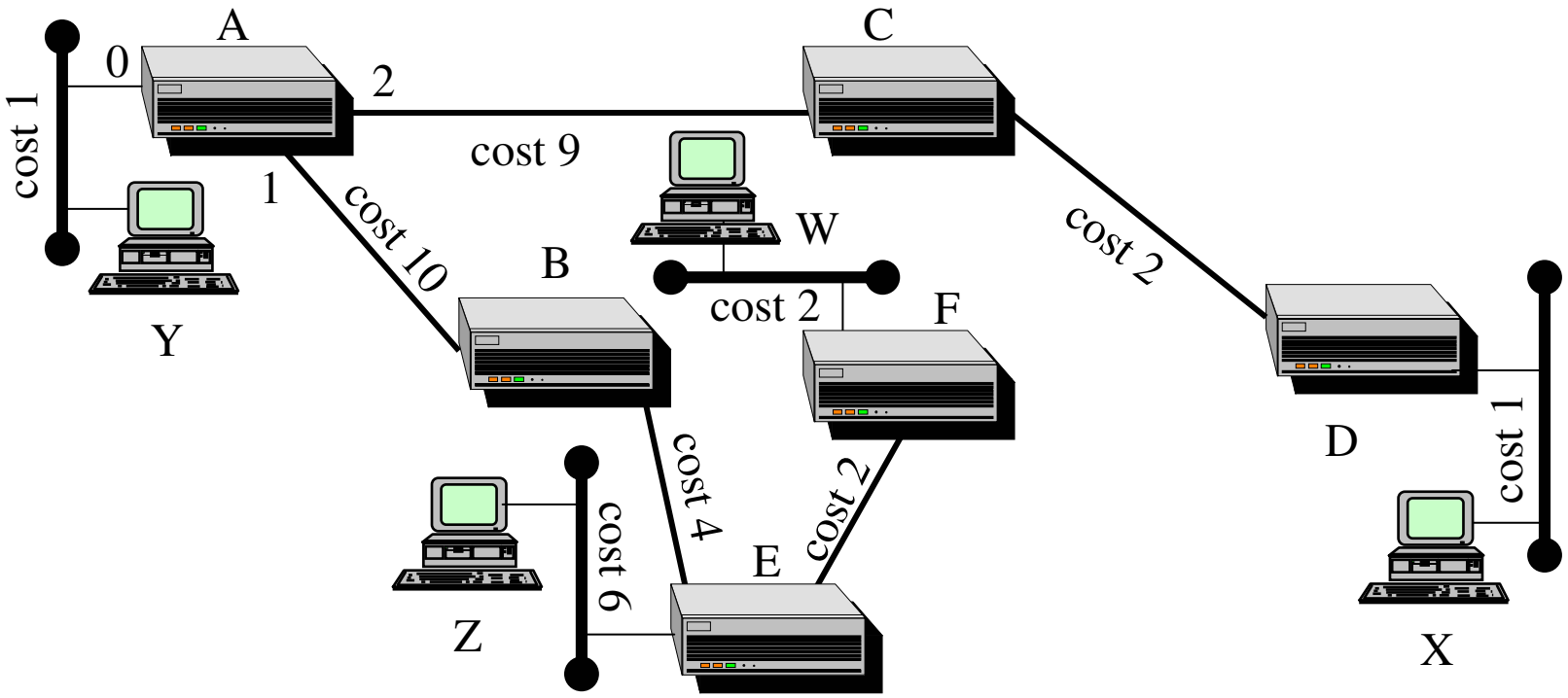
Shortest path tree computed by router A



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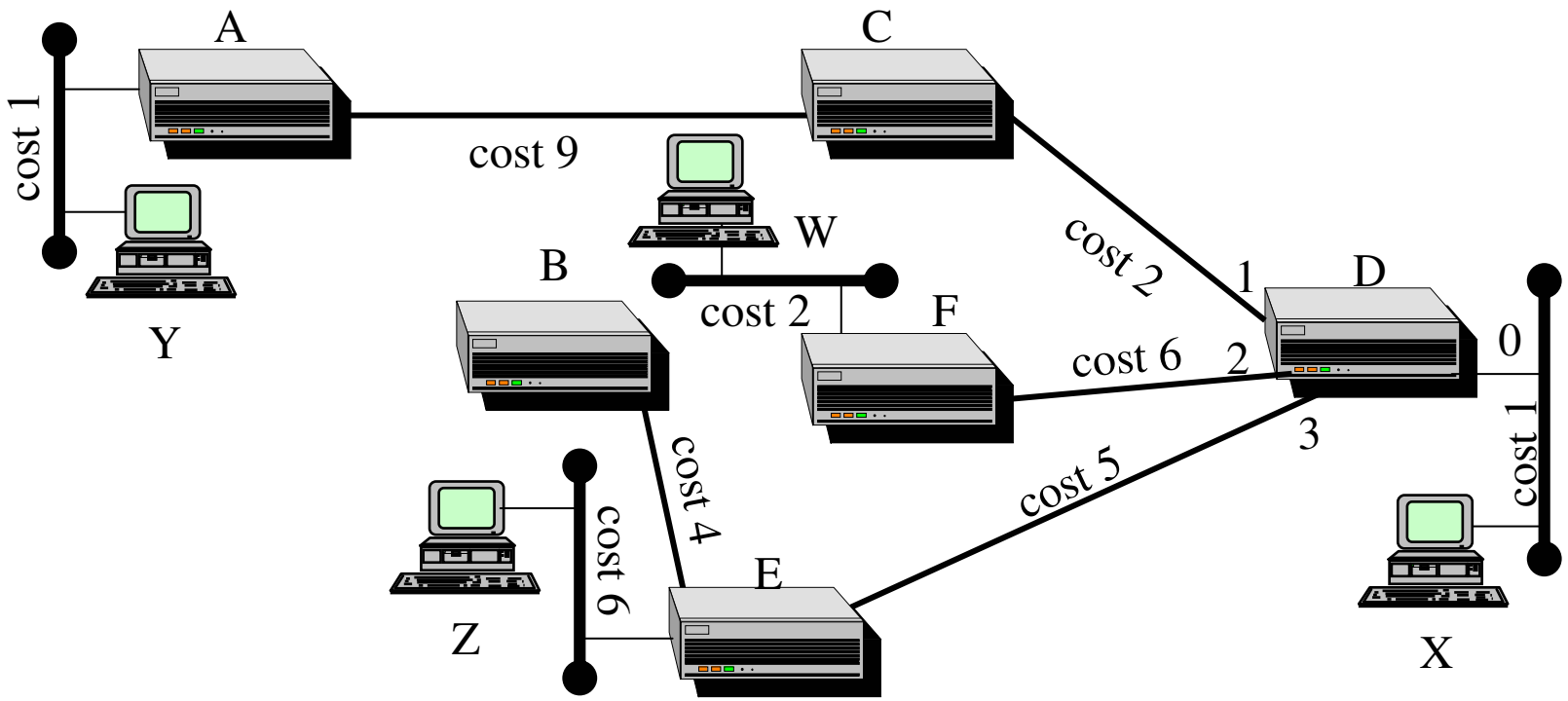
Shortest path tree computed by router D



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Routing table of router A e D

Routing table of A		
Address	Interf.	Cost
B	1	10
C	2	9
D	2	11
E	1	14
F	1	16
X	2	12
Y	0	1
W	1	18
Z	1	20

Routing table of D		
Address	Interf.	Cost
A	1	11
B	3	9
C	1	2
E	3	5
F	2	6
X	0	1
Y	1	12
W	2	8
Z	3	11

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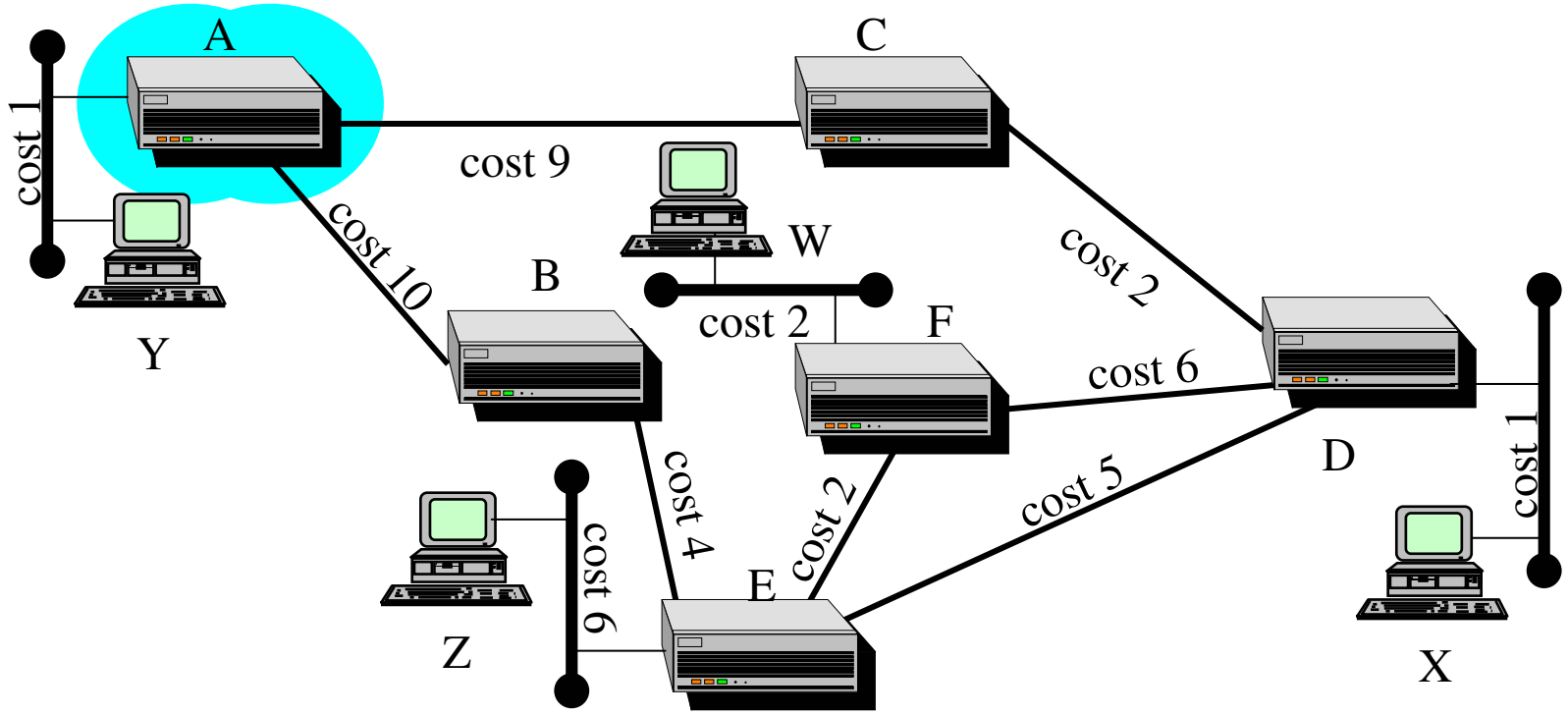
1^0 step to compute shortest path tree di A



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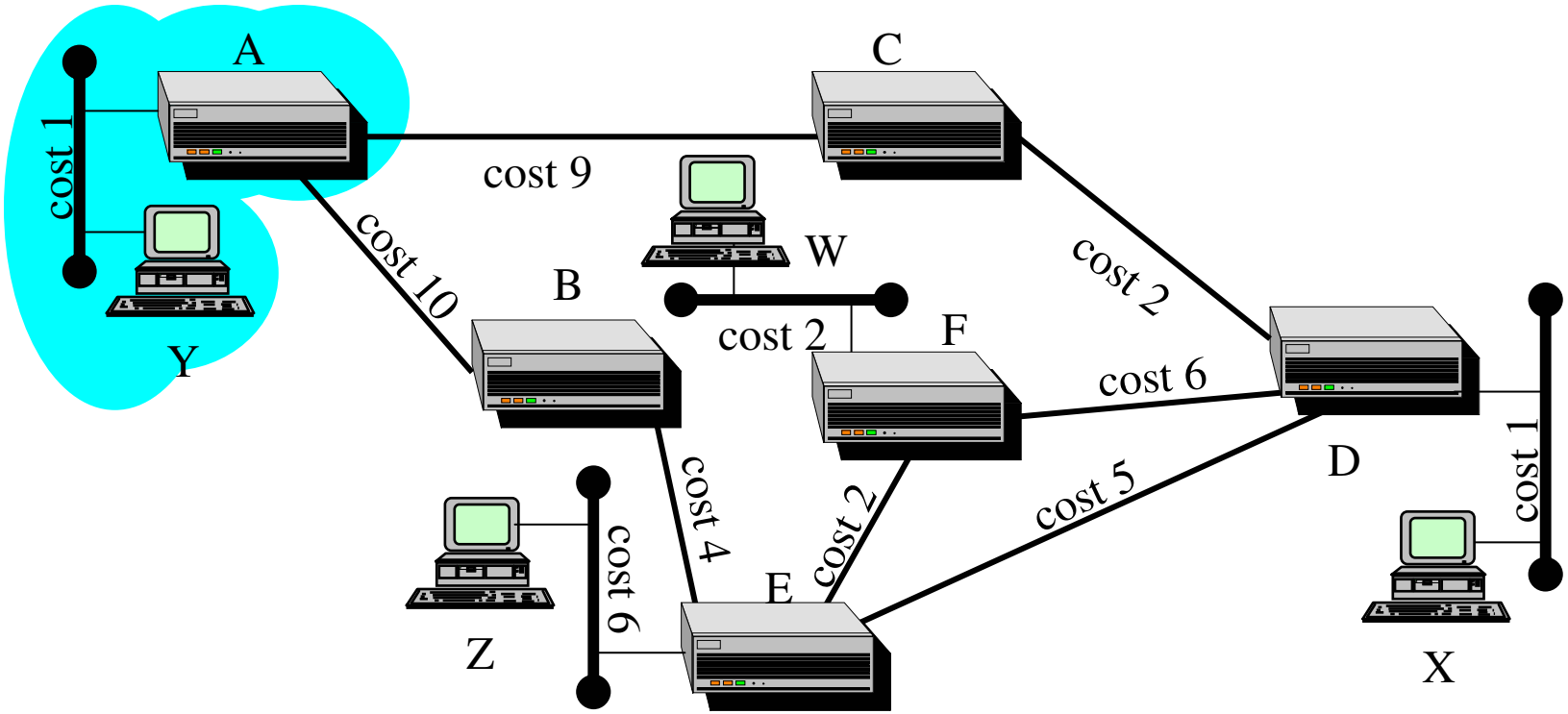
2^0 step to compute shortest path tree di A



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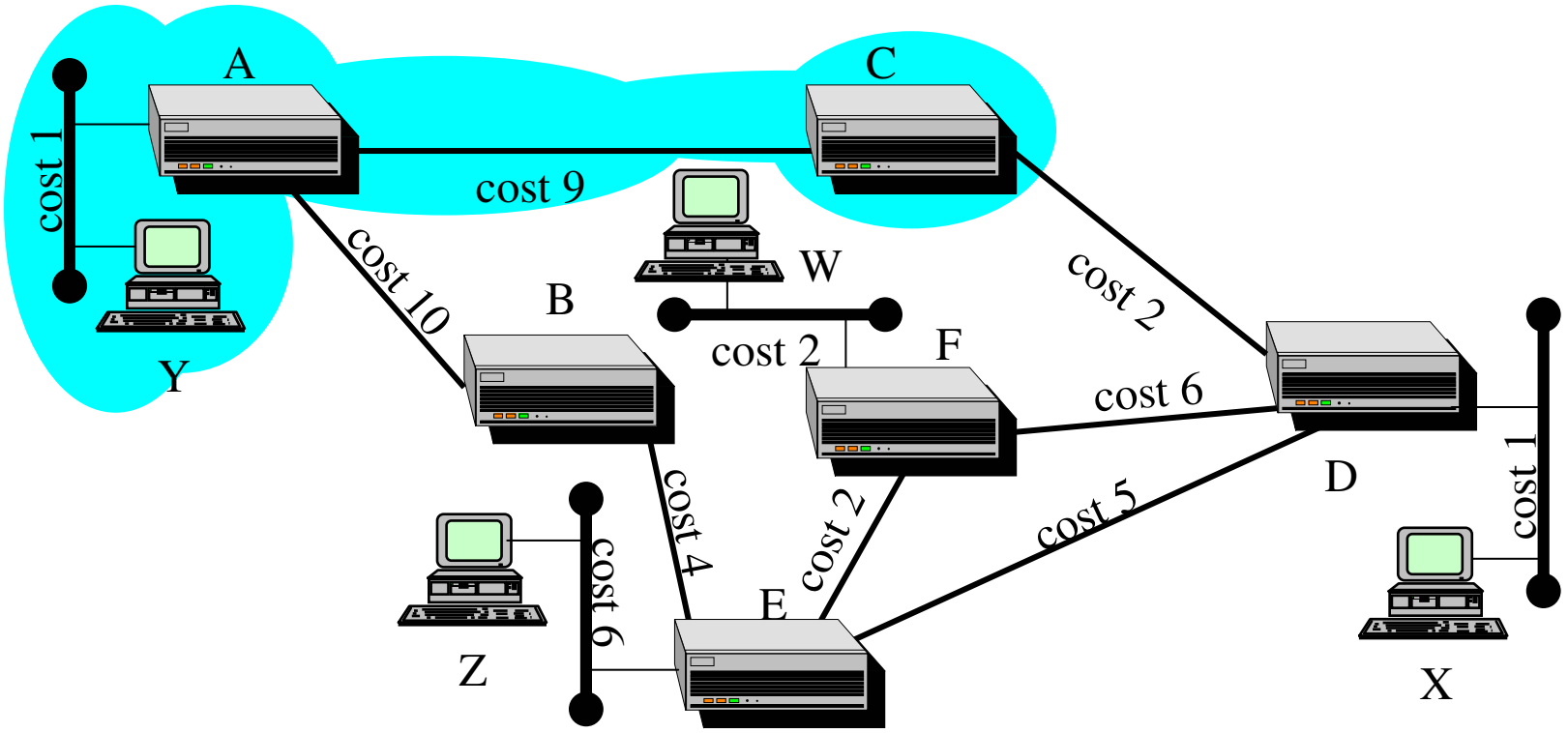
3^0 step to compute shortest path tree di A



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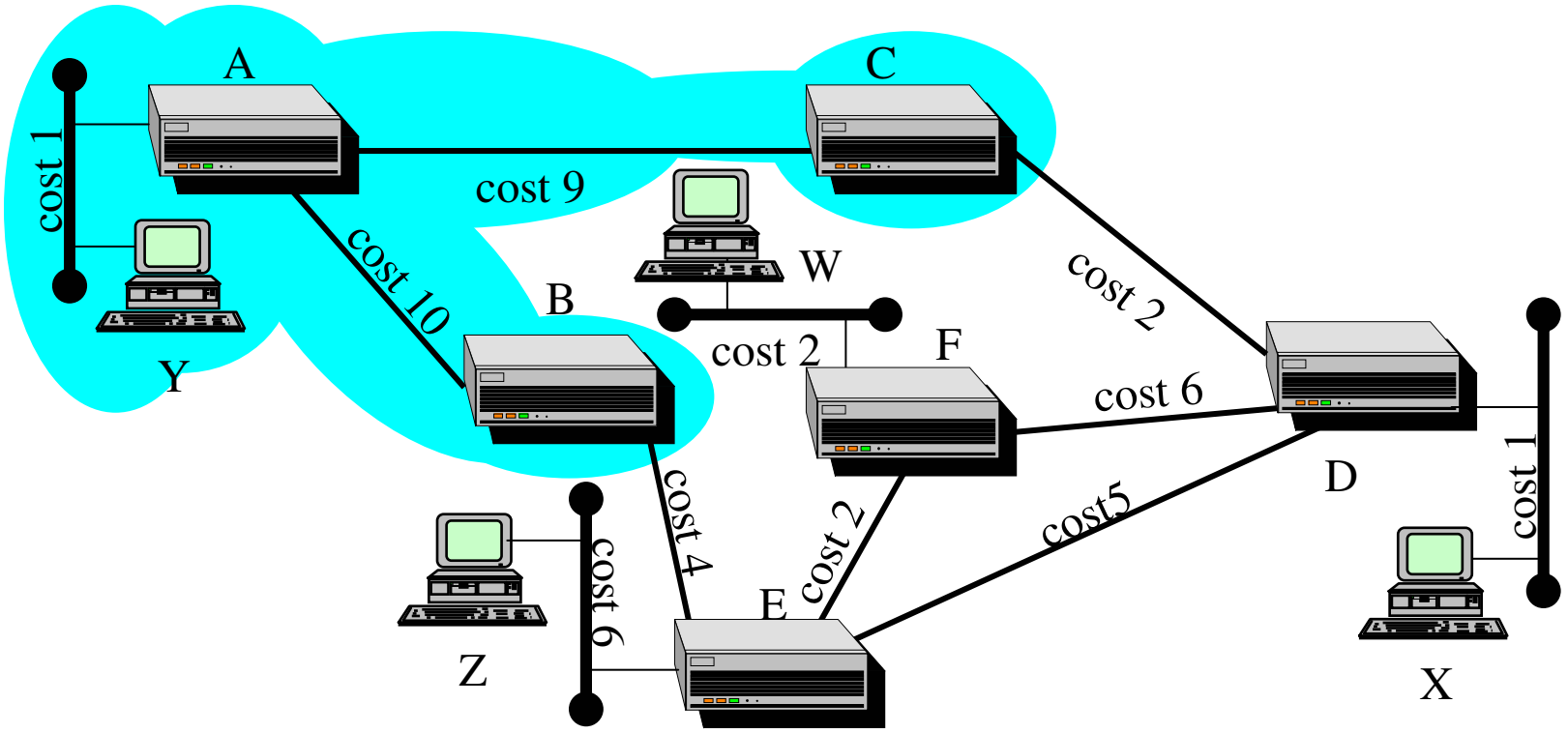
4^0 step to compute shortest path tree di A



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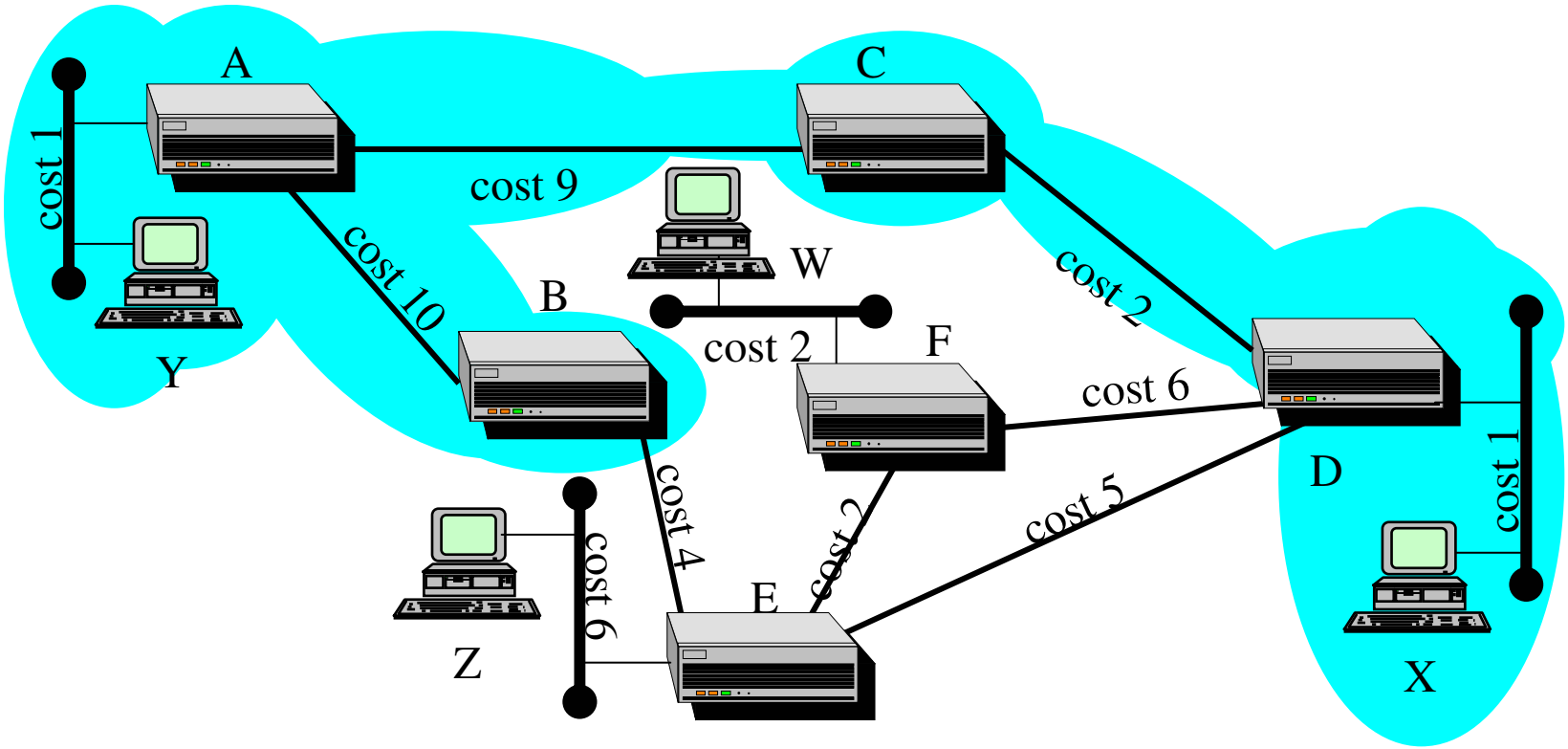
5^0 step to compute shortest path tree di A



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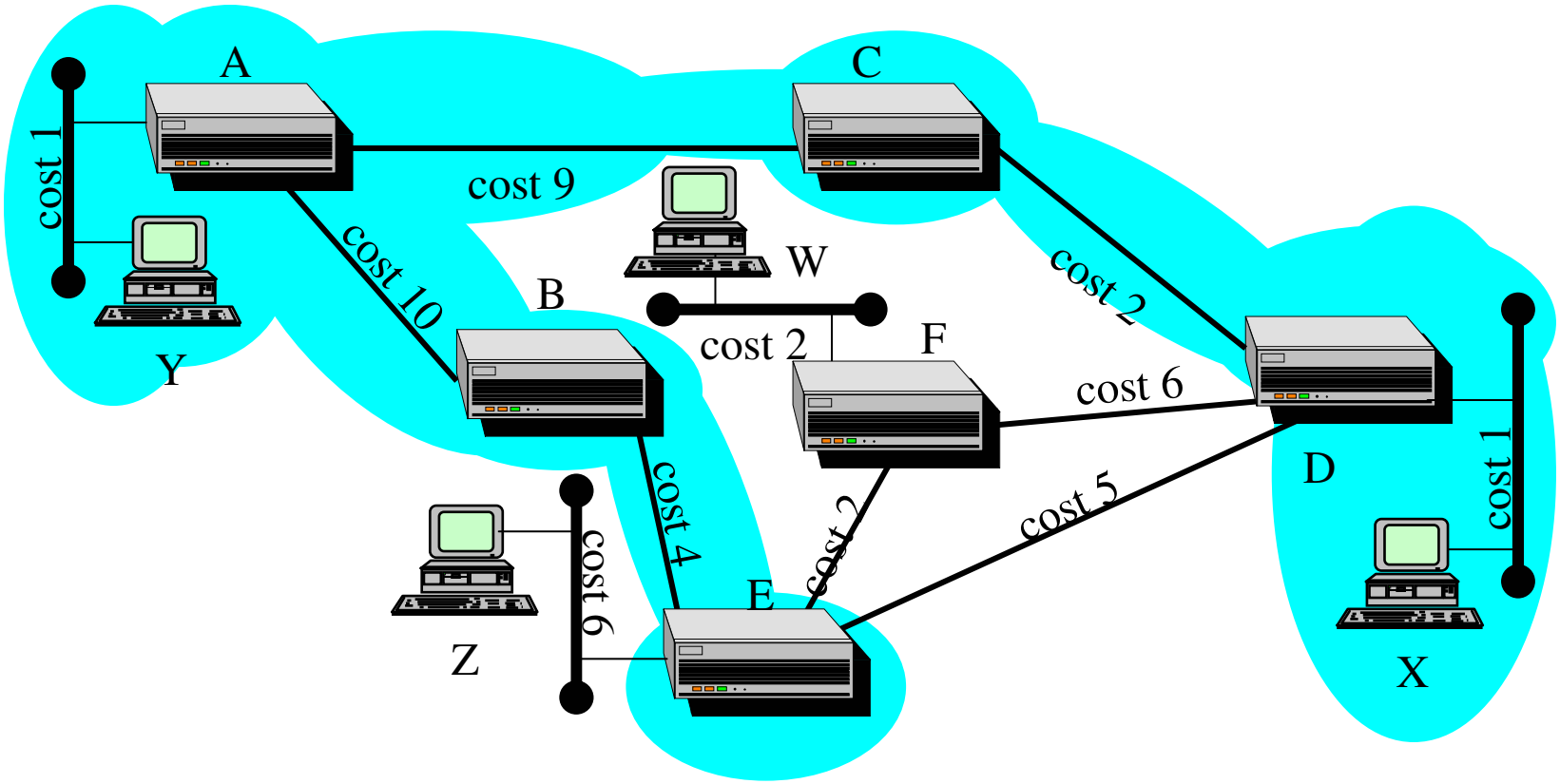
6^0 step to compute shortest path tree di A



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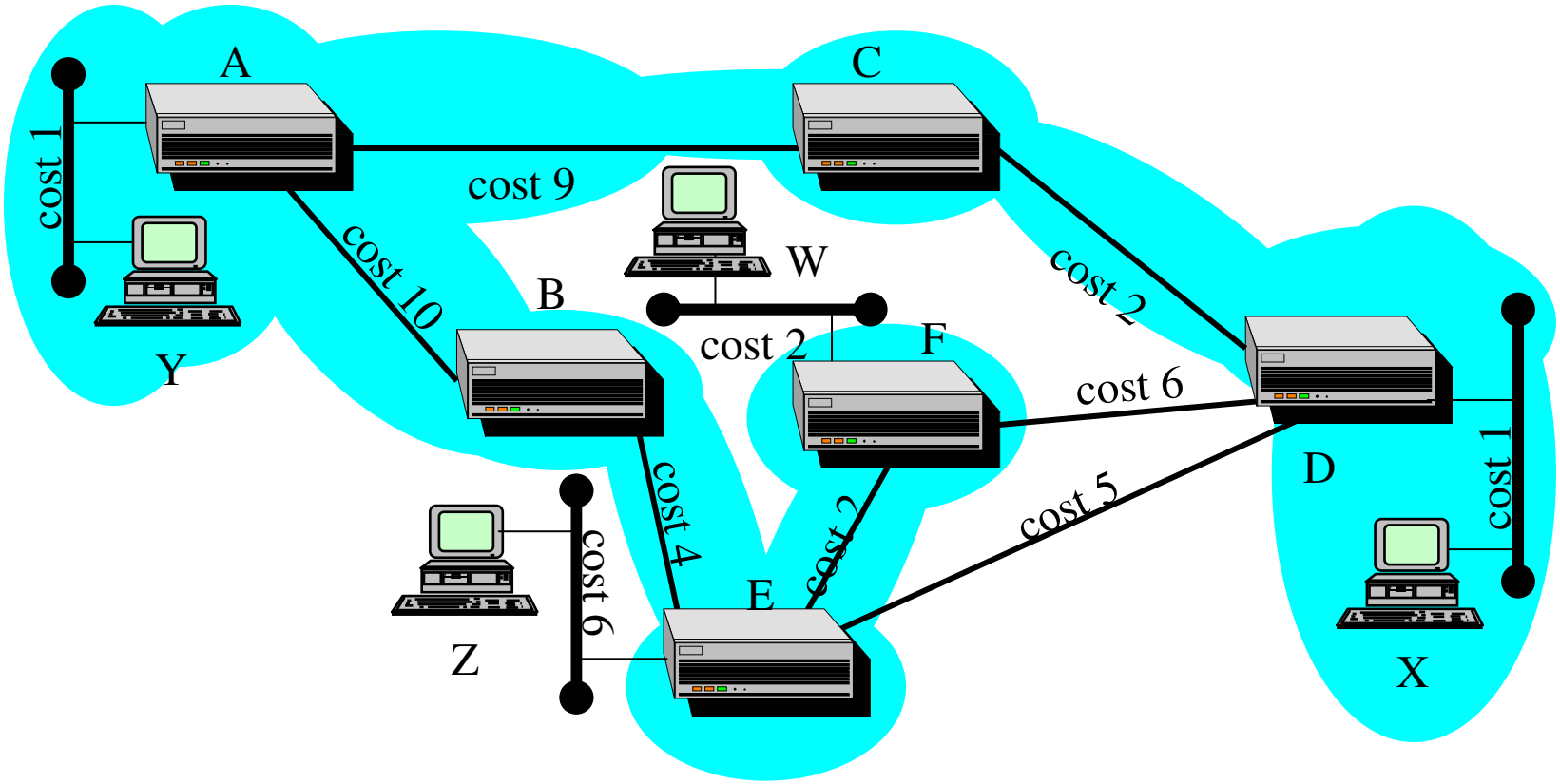
7^0 step to compute shortest path tree di A



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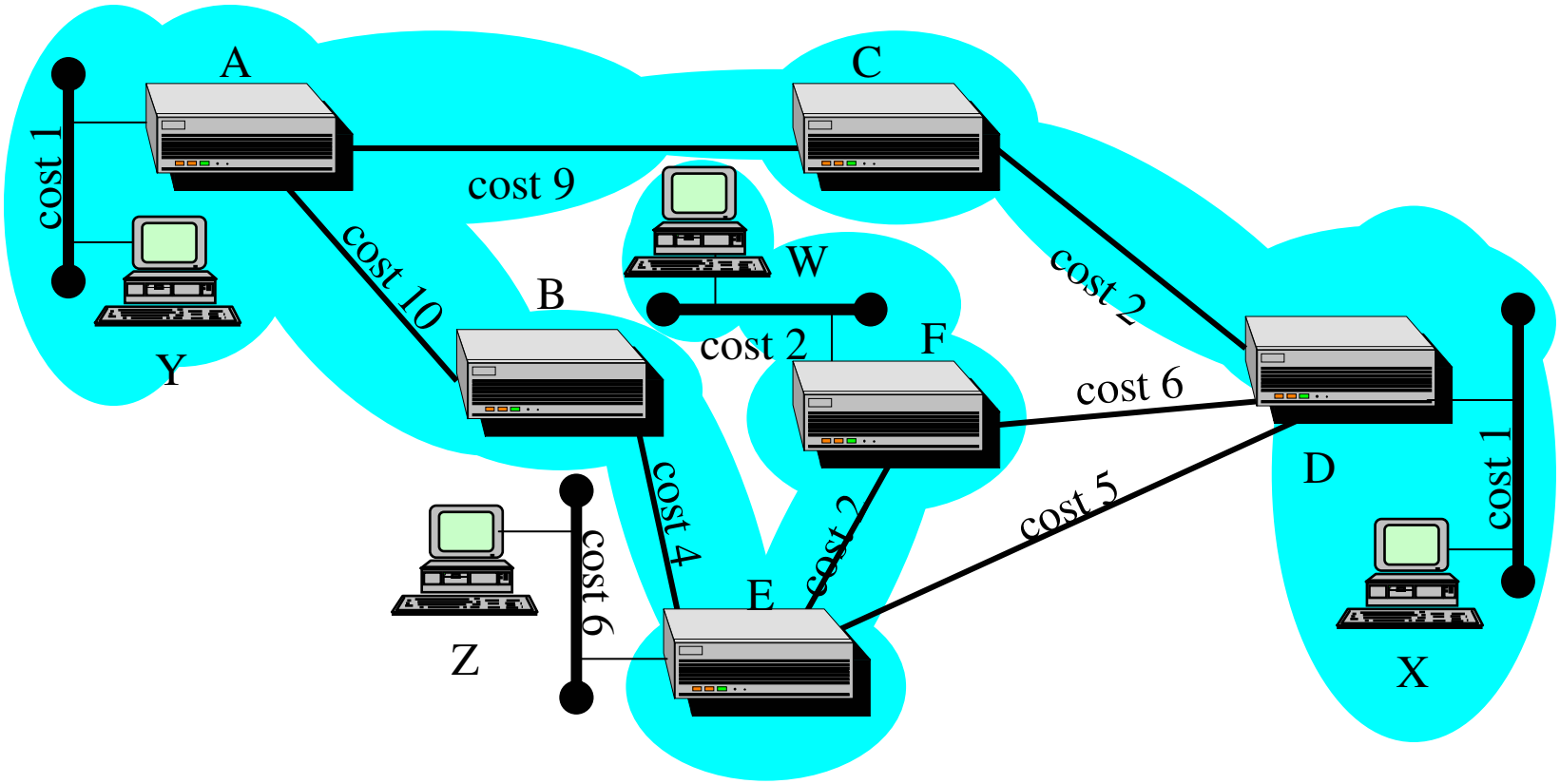
8^0 step to compute shortest path tree di A



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